Intraoperative identification of the internal carotid artery: A safety issue

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The correct intraoperative anatomic identification of the vascular structures in the carotid artery bifurcation is important, and in most operations, this is not a problem. Experiences with two cases are used to suggest a stepwise system to guarantee that anatomic confusion—a confusion that may be fatal—does not occur. (J Vasc Surg 2006;43:159-61.)

The title of this article indicates the existence of a problem in a situation where most surgeons do not realize the possibility of a problem. On the other hand, it is obviously of greatest importance during carotid artery surgery to be absolutely sure that the artery that undergoes endarterectomy is the internal carotid artery (ICA) if the indication is to prevent cerebral embolization. Although extremely rare, there can be mistakes, and anatomic aberrations can mislead the surgeon. The aim of this short report is to present clinical examples and to indicate steps to be taken to exclude the possibility of mistakes.

CASE REPORT

Case 1. A 60-year-old man with diabetes mellitus and hypertension had reversible symptoms of right-sided paresis interpreted as a transient ischemic attack. A duplex ultrasound investigation verified a significant stenosis of the left ICA. He underwent carotid endarterectomy with local anesthesia.

The superior thyroid artery originated from the common carotid artery. The stump back-pressure was 40 mm Hg (systemic pressure, 170 mm Hg), and a contralateral paresis at test clamping showed that insertion of a shunt was indicated. There was restitution of the paresis with shunting, but the patient was drowsy. He subsequently became somnolent and developed paresis of the right arm during the endarterectomy, which was completed with a patch. The shunt was functioning during the procedure, and the total shunt time was 41 minutes.

Postoperatively, the patient's condition deteriorated, the right-sided paresis became total in his arm and leg, and he became unconscious the first postoperative day. A computed tomography (CT) scan showed a large left-sided cerebral infarction, and the patient died after a few hours. At autopsy, it was found that the patch had been placed in the external carotid artery (ECA), with thrombotic occlusion of the ICA where blind endarterectomy had been performed. The two surgeons were experienced vascular surgeons. This case has been evaluated by one of the author's scientific experts to the health care authorities of Sweden.

Case 2. A 67-year-old woman with diabetes mellitus, hypertension, and hyperlipidemia had an accidentally detected >80% asymptomatic ICA stenosis on the left side. The reason for a duplex ultrasound investigation was a bruit detected at a routine health examination. She underwent an endarterectomy and a polyester patch closure with an uneventful postoperative course.

During surgery, the superior thyroid artery was very minute, and there was a relatively large lateral branch from what was interpreted as the ICA (Fig 1). This was verified at further dissection, where no other branches were seen to originate from the ICA, but several other branchings originated from the ECA. To strengthen the identification of the presumed ICA and ECA, the two arteries showed typical Doppler flow patterns for ECA and ICA.

The patient's postoperative course was uneventful. At the follow-up examination with a duplex scan 3 months after the procedure, the branch from the ICA could not be visualized and, presumably, had occluded.

This is the only patient with a branch from the ICA detected during 569 operations in a 10-year period at our institution. Additionally, among about 3,000 duplex ultrasonographies of the carotid arteries at our vascular laboratory, only two patients have been identified with a clear branch from the ICA (Fig 2). Branches from the ICA are not searched for routinely, however, and it is possible that existing ones have been missed. The ICA branch in this case was identified only postoperatively when the anatomy was known from the operation.

DISCUSSION

It is obviously of the greatest importance for patients' safety that complications are avoided during carotid endarterectomy; therefore, the identification of the ICA and ECA must be made as reliably as possible. Masters of surgery must be masters of anatomy. Furthermore, vascular surgery must never become routine, but skill, judgement, and acumen are necessary characteristics of a trained vascu-

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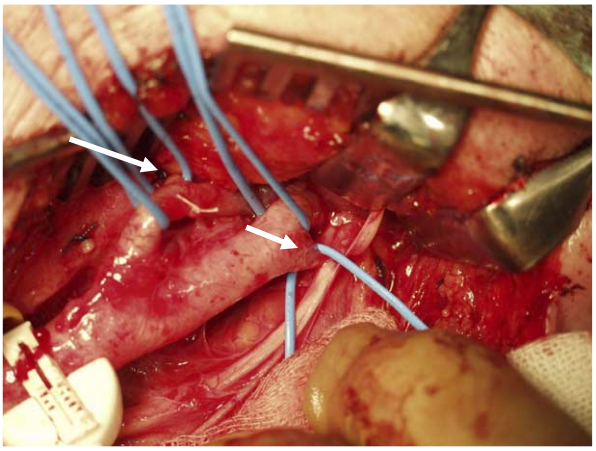

Fig 1. Intraoperative finding of a lateral branch originating from the internal carotid artery *(short arrow)*. Superior thyroid artery *(long arrow)*. The vagal nerve is seen below the carotid artery, and the hypoglossal nerve is held by the retractor.

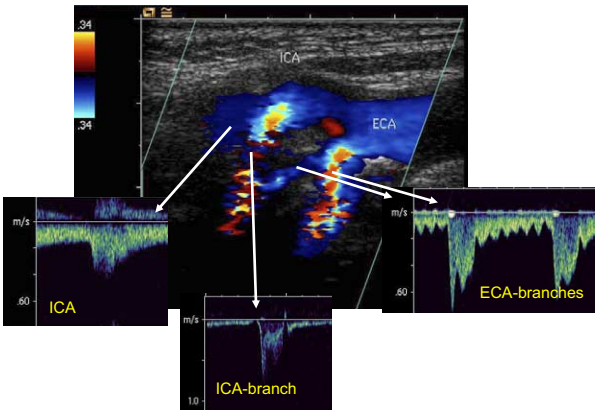

Fig 2. Duplex sonography scans show internal carotid artery *(ICA)* with a branch *(ICA-branch)* and external carotid artery *(ECA)* with branches *(ECA-branches)*.

lar surgeon. This is all the more important as only a few carotid endarterectomies today are performed after an angiography that shows anatomic details.

A common rule of thumb is that the ECA has branches that the cervical part of the ICA does not. There are, however, exceptions to this rule. In principle, there are two categories of aberrant extracranial carotid vessels: anomalies of persistent fetal connections from the ICA and anomalies of the origin of external carotid artery branches. The most common anomalies resulting in branches arising from the extracranial ICA are that the ascending pharyngeal artery or the persistent hypoglossal artery originate from the ICA near the bifurcation.[1-4] Other anomalies that have been reported are occipital, laryngeal, and sternocleidomastoidal arteries (usually branches of the ECA) originating from the ICA.[1,5-10] The embryologic background of these arterial anomalies has been previously summarized.[6,11] To judge from our combined operative and duplex experience, the frequency of branches from the ICA is <1%.

To secure the anatomic identification of the ICA intraoperatively, the following steps could be taken:

- Morphologic criteria are the most important and work in almost all cases. This means identification of the carotid bifurcation with the ICA, with its slight sinus dilatation (carotid bulb), laying laterally and posterior to the ECA, which has a very early branch in the form of the superior thyroid artery. However, this artery has its origin from the common carotid artery in about 10% of patients, but with great variations between reports.[12,13] An important technical point is adequate exposure of the internal and external carotid arteries and branches, which may be difficult when the procedure is done under local anesthesia and which may explain the outcome in the first patient.
- If the superior thyroid artery originates from the common carotid artery, the next ECA branch (ascending pharyngeal, lingual, sternocleidomastoidal, and often further up, occipital and fascial) must be dissected and identified. Additionally, if both the "internal" and the "external" carotid arteries have early branches, dissection must proceed until the next branch is encountered, which practically always is from the external artery. More than one branch from the cervical ICA has been reported only once.[14] Furthermore, one patient with an aplastic ECA in whom all the branches originated from the ICA has been documented.[15]
- If an uncertainty still exists, flow assessment is performed to identify the typical low-resistance flow profile of the ICA. At times, however, differentiating between the ECA and ICA based on flow profile criteria alone can be difficult.
- If flow measurement is not possible or if some element of uncertainty still exists, an intraoperative angiography must be performed. An intraoperative angiography would probably have added information in our second case. The indication for intraoperative angiography should be liberal. The use of radiopaque markers can also be of help in the anatomic interpretation.

It is rare that all the steps described here are needed to identify the ICA. However, it is important not to be "convinced" by an intraoperative impression of how the ICA usually looks, even for experienced surgeons, but to have very well defined criteria to correctly identify the anatomy of these arteries. Additionally, if there are problems with clearly identifying the carotid artery during endarterectomy because the use of local anesthesia limits the exposure, converting to general anesthesia will make adequate exposure less difficult.

Following these precautions should exclude the risk for anatomic confusion of the arteries during carotid endarterectomy. Having the anatomic knowledge of variants and being confident in the operative findings is safer than to advocate routine preoperative angiography. Furthermore, none of the potential preoperative investigations (ultra-

sonography or various angiographic methods) can replace meticulous surgical technique.

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